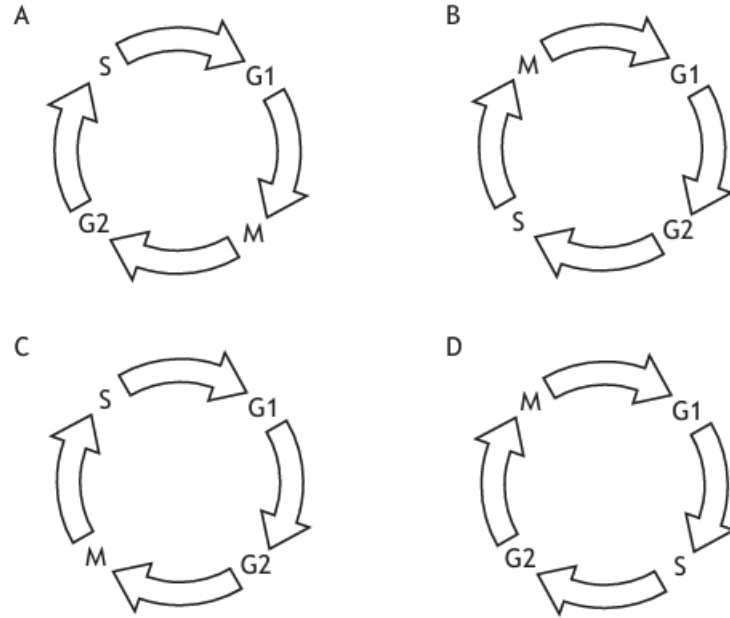
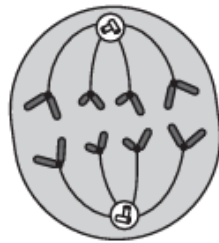


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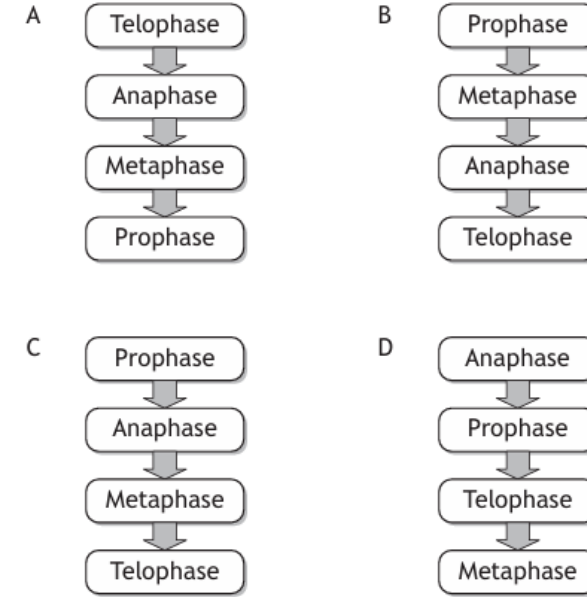


2 The diagram represents a cell in which stage of mitosis?



- A Metaphase
- B Prophase
- C Telophase
- D Anaphase

3 Which of the following diagrams represents the sequence of stages involved in mitosis?



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- A phosphorylation of specific proteins
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Figure 1

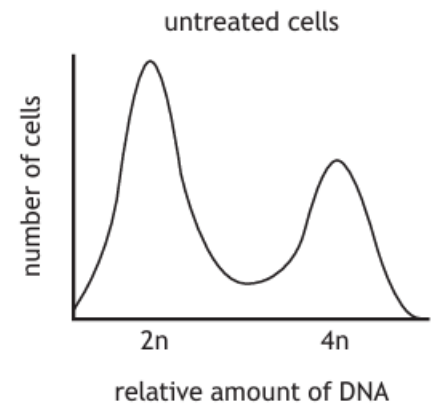
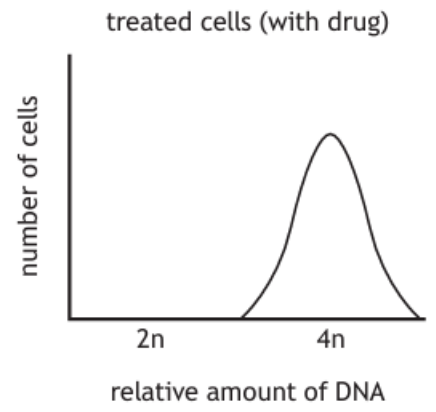


Figure 2



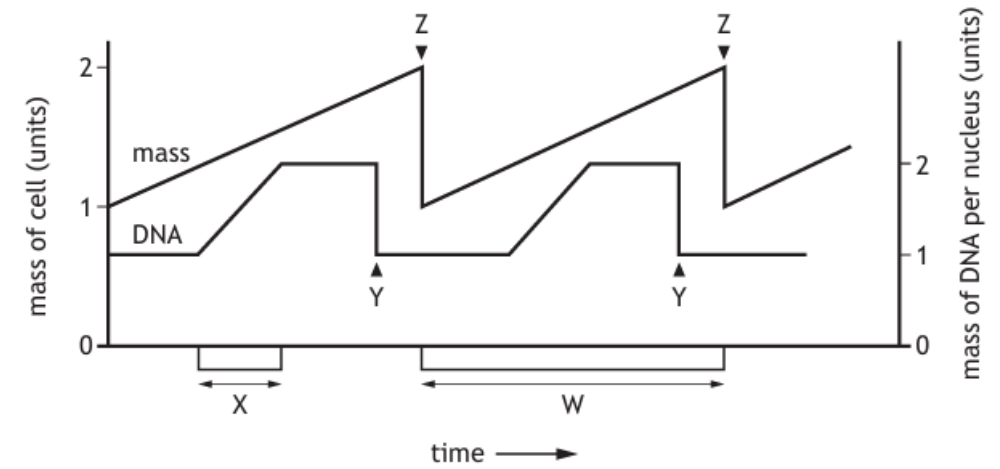
At which phase(s) of the cell cycle does this drug act?

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7 At which phase of the cell cycle is the retinoblastoma protein phosphorylated allowing progression to the next phase of the cycle?

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- B S
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- D M

8 The diagram shows the changes in cell mass and DNA content in a cell during two mitotic cell divisions.



Which row in the table identifies the cellular events labelled W, X, Y or Z in the diagram?

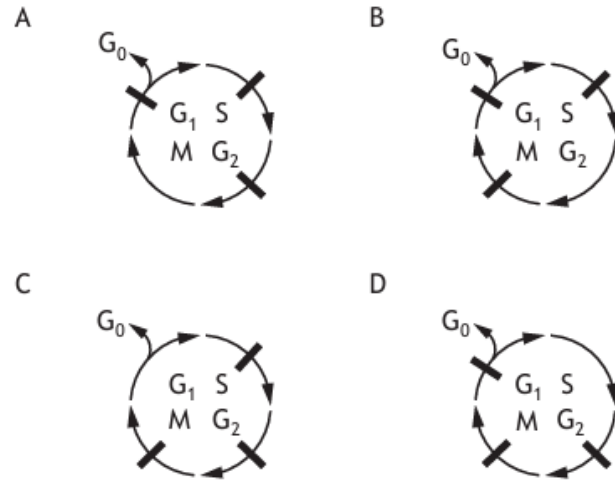
	Telophase	Cytokinesis	DNA replication
A	X	Y	W
B	Y	Z	W
C	Y	Z	X
D	Z	W	X

9 During the cell cycle, sufficient phosphorylation by G_1 cyclin-dependent kinases allows

- A the cell to pass into M phase
- B p53 to be activated
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Checkpoint is represented by 



11 Which line in the table below correctly matches checkpoint conditions with the stage of the cell cycle where they apply?

	<i>Success of DNA replication</i>	<i>Cell size</i>	<i>Chromosome alignment</i>
A	S	G ₁	M
B	G ₂	M	S
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12 The role of cytokinesis is to

- A divide cytoplasm
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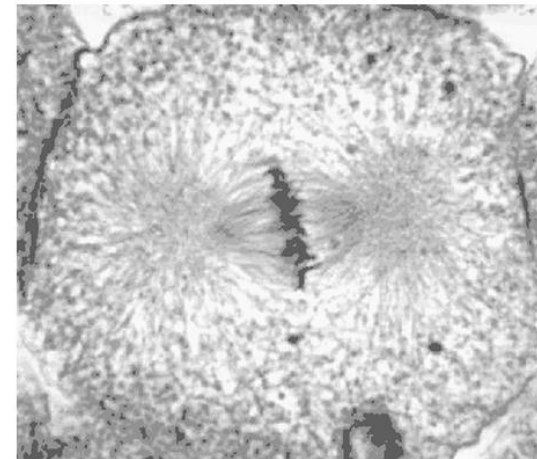
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	<i>Chemotherapy drug</i>	
	<i>Paclitaxel</i>	<i>Cisplatin</i>
A	G ₂	S
B	M	G ₁
C	S	M
D	M	S

The photograph shows a stage in mitosis.

14

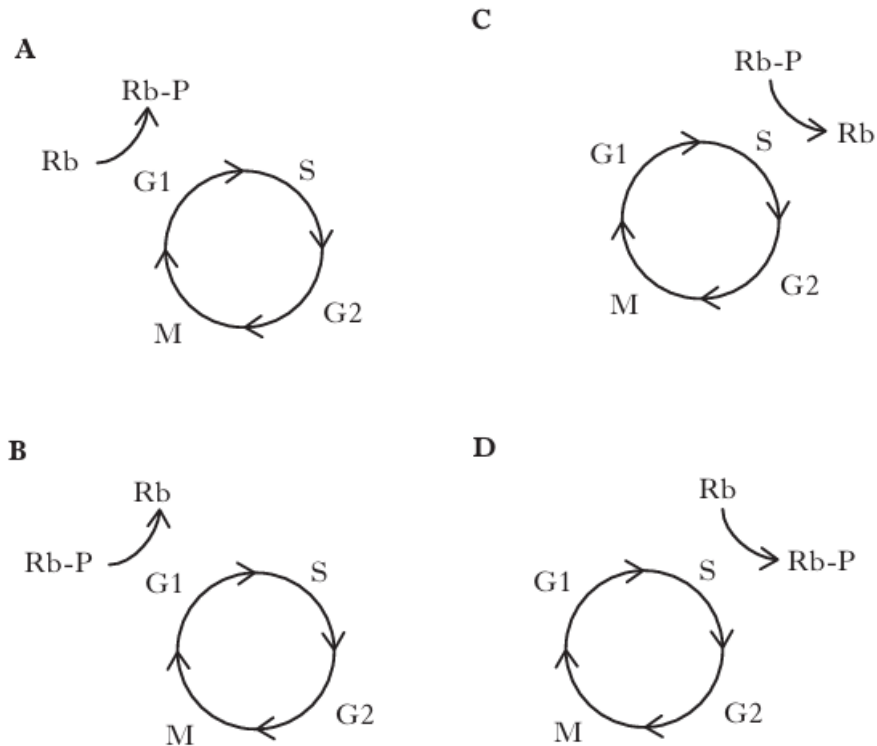


Which stage is shown?

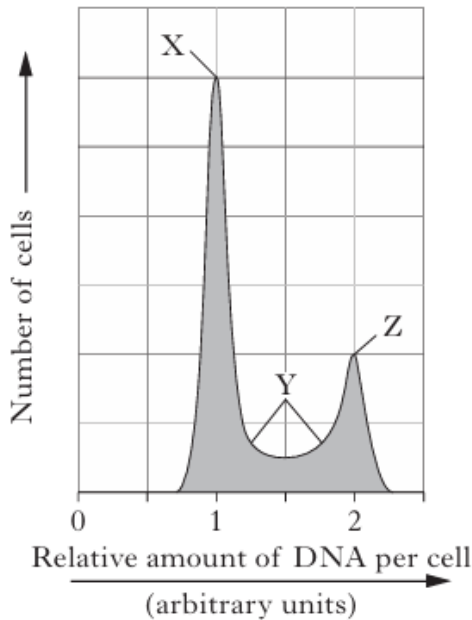
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15 Retinoblastoma protein (Rb) has a role in regulating progress through the cell cycle. It can be phosphorylated (Rb-P) or unphosphorylated (Rb).

Which of the following diagrams represents how the protein is altered to let the cycle progress?



16 The figure below shows the relative DNA content of cells from a culture.



In which two phases of the cell cycle are cells in region Z?

- A G1 and S
- B S and G2
- C G2 and M
- D M and G1

Microtubules are found in all eukaryotic cells.

1 (a) Name the globular protein of which microtubules are composed.

(b) Name the structure from which microtubules radiate.

2 Give a feature of metaphase cells that would allow them to be identified under the microscope.

1

3 Once mitosis is complete, the cytoplasm separates to give two daughter cells.

State the term used to describe this process.

1

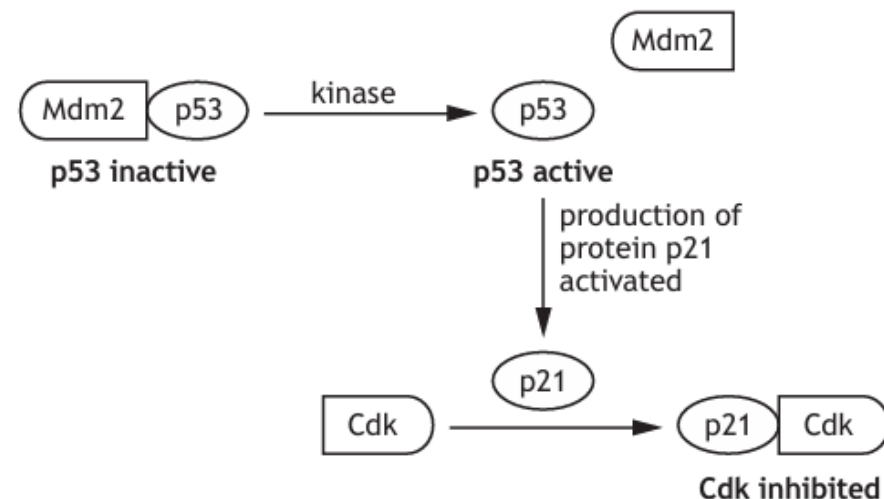
4 Describe the structure of spindle fibres and explain their role in the movement of chromosomes during cell division.

4

5 The protein p53 plays an important role in controlling cell division. The diagram represents how the activation of p53 can result in arrest of the cell cycle.

1

1



(a) Suggest why the action of kinase disrupts the association between the two proteins Mdm2 and p53.

1

(b) Explain why binding of p21 protein to cyclin dependent kinase (Cdk) prevents the cell cycle from progressing.

2

6 Further investigation of the tumour cells revealed that they had a mutated version of the gene coding for the retinoblastoma protein, resulting in failure of the G1 checkpoint.

(i) Describe the role of cyclins in cell cycle progression. 1

(ii) Explain how the mutation in these tumour cells leads to loss of cell cycle control. 2

7. Underline one of the alternatives in each pair of brackets to make the following sentences correct. 1

Failure of the G1 checkpoint in these cells will result in them

taking $\left\{ \begin{matrix} \text{more} \\ \text{less} \end{matrix} \right\}$ time to progress through the cell cycle due to

spending $\left\{ \begin{matrix} \text{more} \\ \text{less} \end{matrix} \right\}$ time in cell cycle arrest.

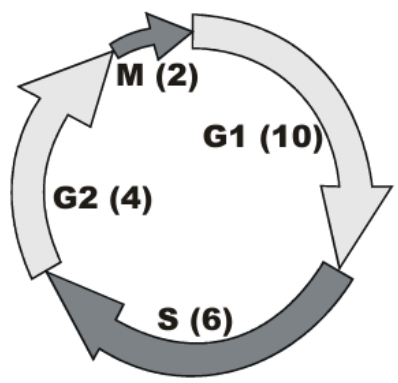
8. Describe what happens during the G1 phase of the cell cycle. 1

9. Tag has also been shown to bind to and inactivate the retinoblastoma protein (Rb).

Explain how the interaction of Tag with Rb would disrupt the normal control of cell division. 2

10

The following diagram represents the cell cycle sequence. The numbers are the average number of hours spent in each stage.



(a) Name the transcription factor inhibitor that is phosphorylated by the G1 cyclin-dependent kinases.

1

(b) State the function of the S stage.

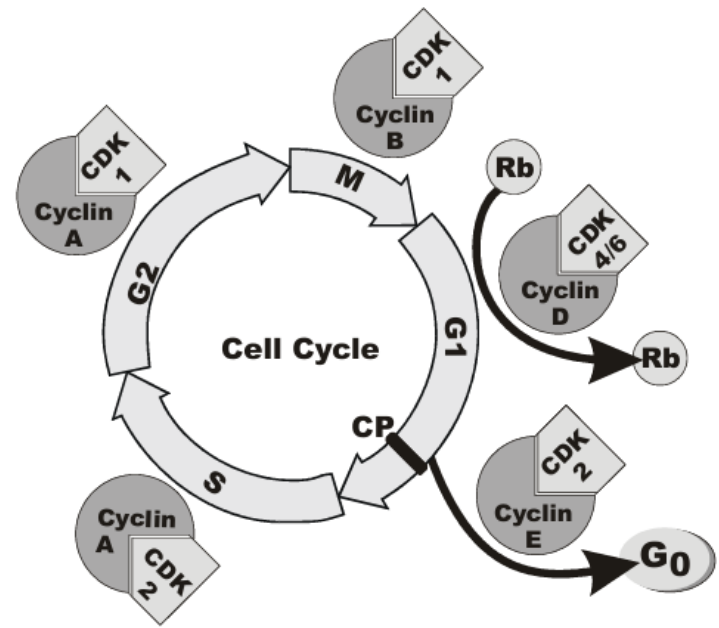
1

(c) Name the stage of mitosis where the chromosomes are arranged on the equator of the cell.

1

11

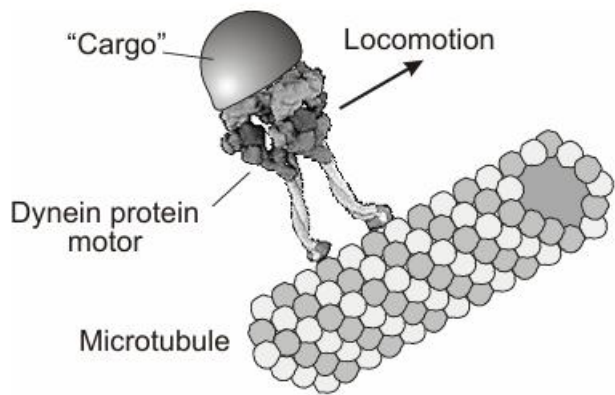
The diagram below represents the control of the cell cycle by Cdk.



Describe the action of Cyclin D CDK on retinoblastoma (Rb) in the control of the cell cycle.

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12 The diagram represents a dynein motor protein “walking” a vesicle along a microtubule.



(a) Name the globular protein subunits of microtubules.

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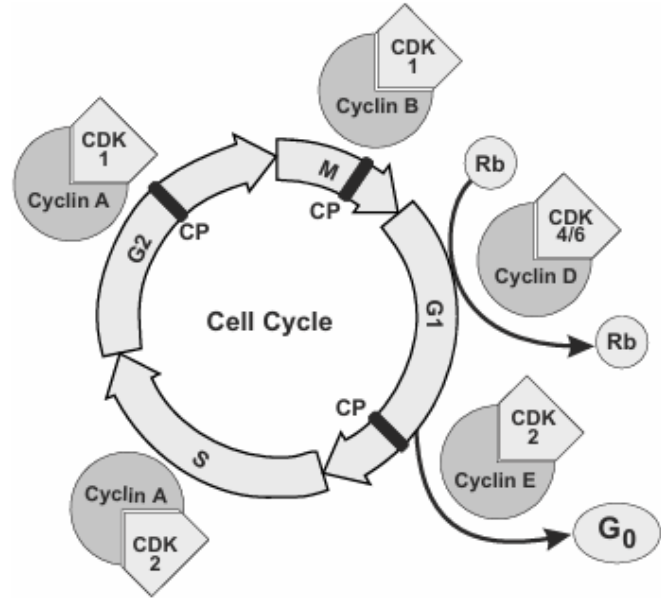
(b) The cytoskeleton is dismantled to form the spindle. Name the stage of mitosis when the chromatids are separated.

1

(c) Explain the role of retinoblastoma (Rb) in the control of the cell cycle.

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13 The diagram below represents the control of the cell cycle by Cdk.



(a) State what is being monitored in a G1 cell before the cycle can continue.

1

(b) (i) Explain how the retinoblastoma protein (Rb) acts as a checkpoint during G1.

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(ii) Explain how an accumulation of G1 cyclin-CDK removes the Rb checkpoint and allows the S phase to begin.

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(c) State what occurs during the S phase.

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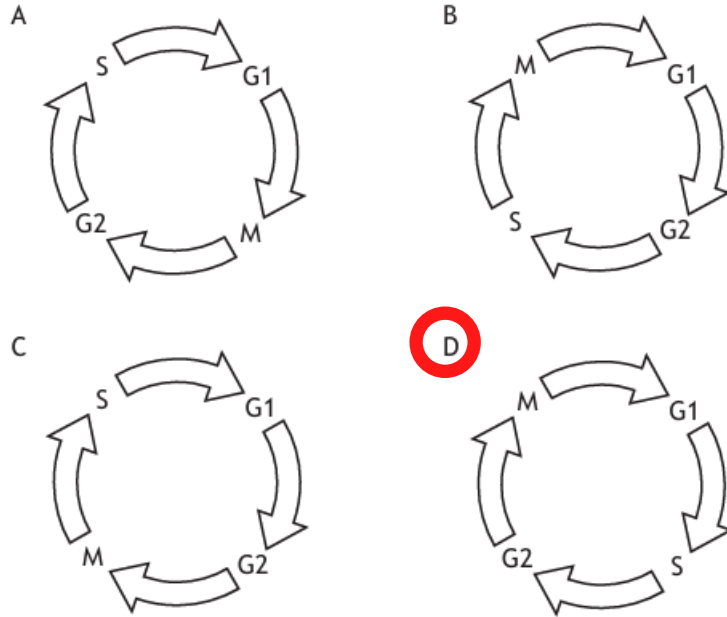
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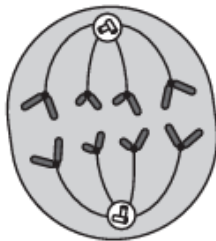
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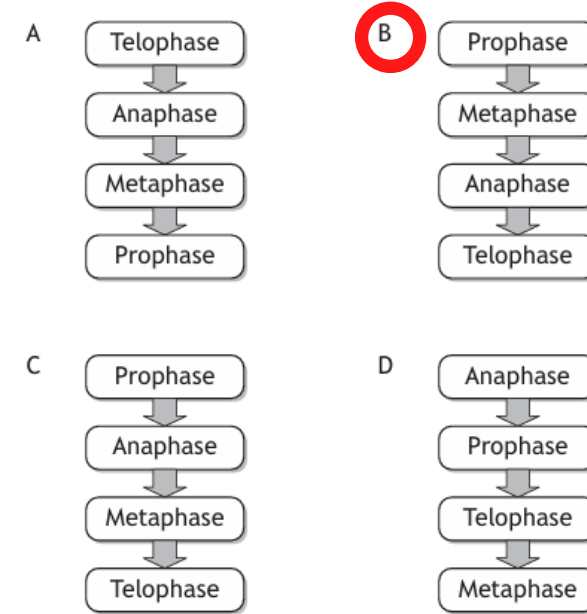


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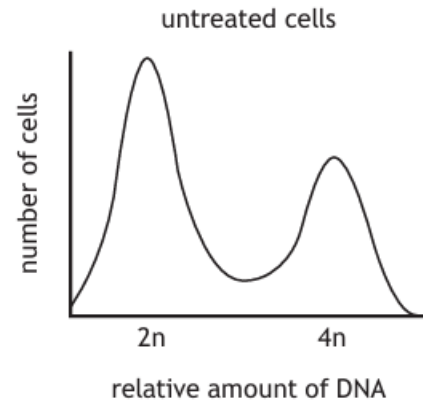
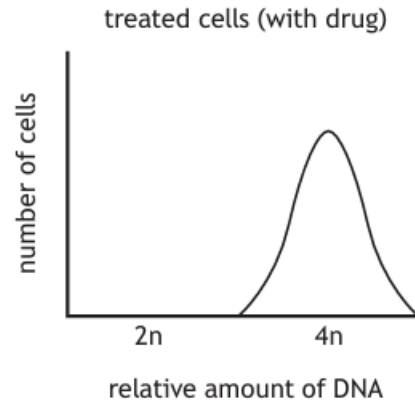


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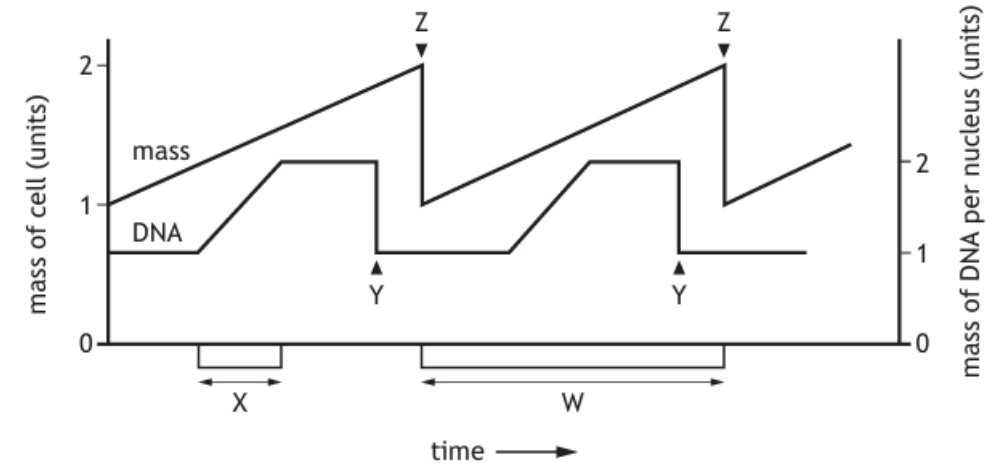
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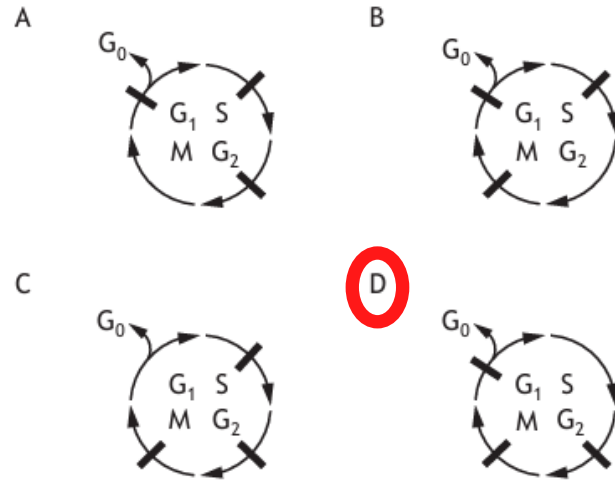
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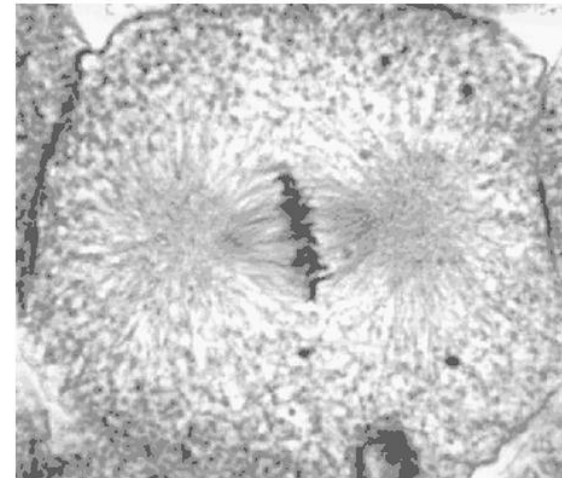
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14 The photograph shows a stage in mitosis.

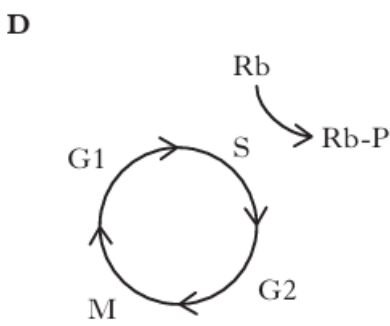
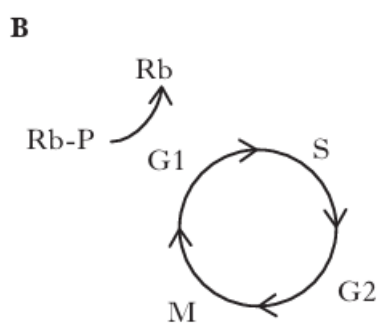
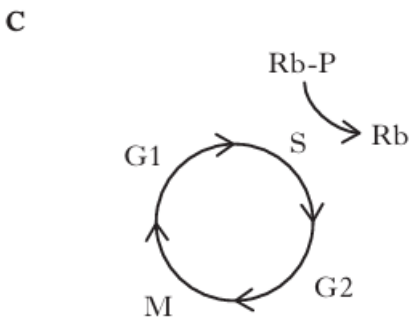
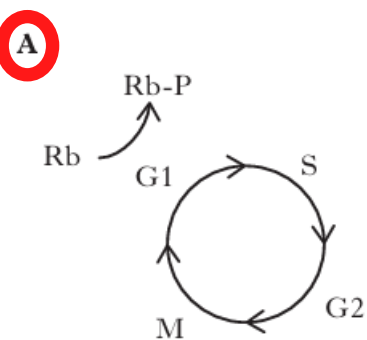


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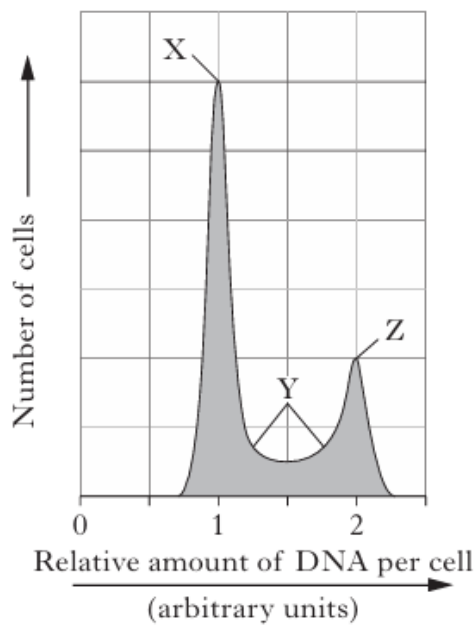
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Which of the following diagrams represents how the protein is altered to let the cycle progress?



16 The figure below shows the relative DNA content of cells from a culture.



In which two phases of the cell cycle are cells in region Z?

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- B S and G2
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Microtubules are found in all eukaryotic cells.

- 1 (a) Name the globular protein of which microtubules are composed.

Tubulin

- (b) Name the structure from which microtubules radiate.

MTOC/ centrosome.

- 2 Give a feature of metaphase cells that would allow them to be identified under the microscope.

Chromosomes aligned at the metaphase plate

- 3 Once mitosis is complete, the cytoplasm separates to give two daughter cells.

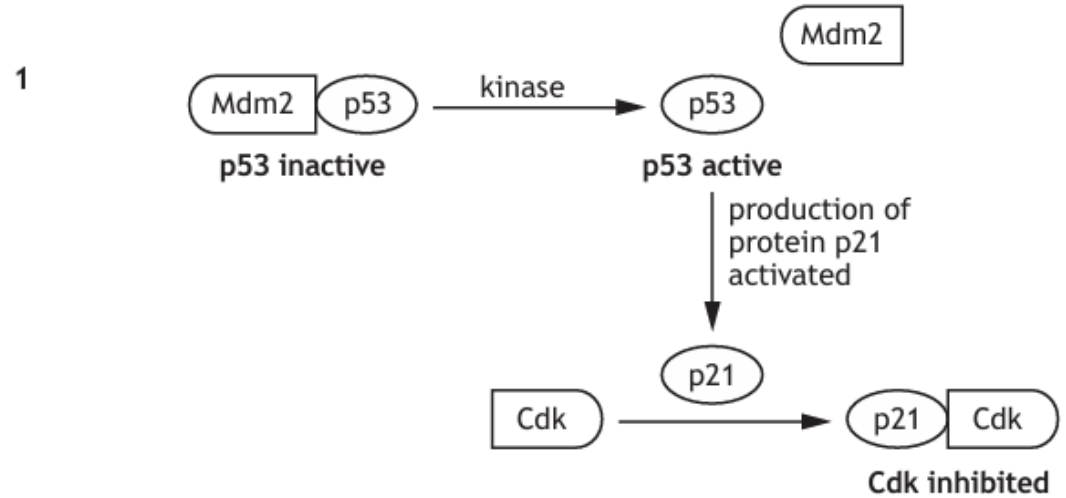
State the term used to describe this process.

Cytokinesis

- 4 Describe the structure of spindle fibres and explain their role in the movement of chromosomes during cell division.

1. Cell division requires remodelling of cytoskeleton
2. Spindle fibres made of microtubules
3. Composed of tubulin
4. Hollow cylinders/tubes
5. Attach to centromere/kinetochores
6. Radiate from MTOC/centrosome
7. Spindle fibres contract
8. Separate chromatids

- 5 The protein p53 plays an important role in controlling cell division. The diagram represents how the activation of p53 can result in arrest of the cell cycle.



- (a) Suggest why the action of kinase disrupts the association between the two proteins Mdm2 and p53.

Adds a phosphate which changes conformation of protein

- (b) Explain why binding of p21 protein to cyclin dependent kinase (Cdk) prevents the cell cycle from progressing.

CDK's cannot phosphorylate Rb (1)

Rb prevents entry into S phase (1)

6 Further investigation of the tumour cells revealed that they had a mutated version of the gene coding for the retinoblastoma protein, resulting in failure of the G1 checkpoint.

(i) Describe the role of cyclins in cell cycle progression. 1

Combine with/activate Cdk

(ii) Explain how the mutation in these tumour cells leads to loss of cell cycle control. 2

Rb won't inhibit transcription

Proteins needed for DNA replication not produced

7. Underline one of the alternatives in each pair of brackets to make the following sentences correct. 1

Failure of the G1 checkpoint in these cells will result in them taking more time to progress through the cell cycle due to spending more time in cell cycle arrest.

8. Describe what happens during the G1 phase of the cell cycle. 1

Cell increases in size/mass

9. Tag has also been shown to bind to and inactivate the retinoblastoma protein (Rb). 2

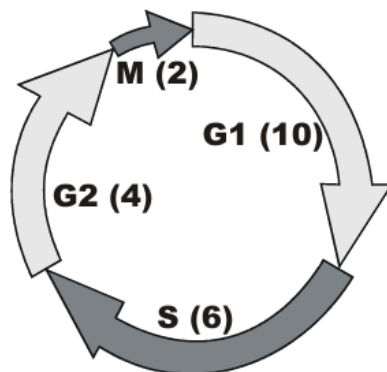
Explain how the interaction of Tag with Rb would disrupt the normal control of cell division.

Rb acts at the G1 checkpoint, preventing progression to S phase.

If Rb is inhibited, the cell will move into S phase when there is insufficient phosphorylation of Rb and should be held at G1 checkpoint.

10

The following diagram represents the cell cycle sequence. The numbers are the average number of hours spent in each stage.



- (a) Name the transcription factor inhibitor that is phosphorylated by the G1 cyclin-dependent kinases.

Rb/retinoblastoma

1

- (b) State the function of the S stage.

DNA replication

1

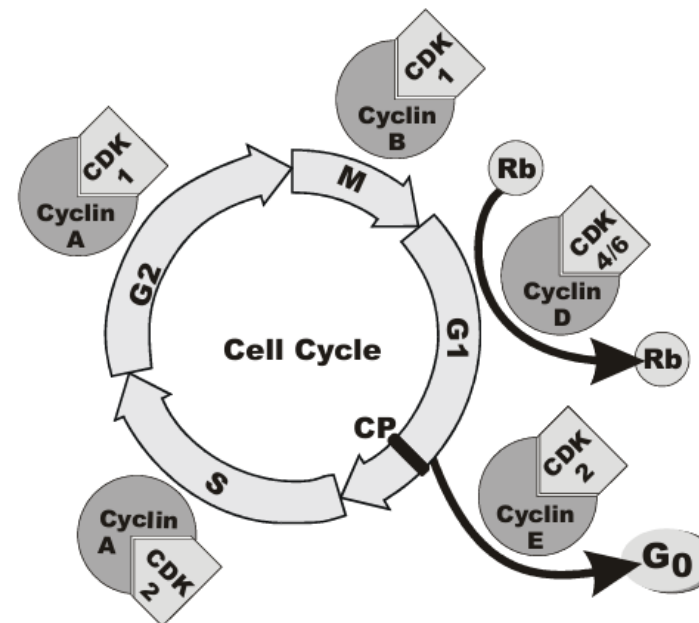
- (c) Name the stage of mitosis where the chromosomes are arranged on the equator of the cell.

metaphase

1

11

The diagram below represents the control of the cell cycle by Cdks.



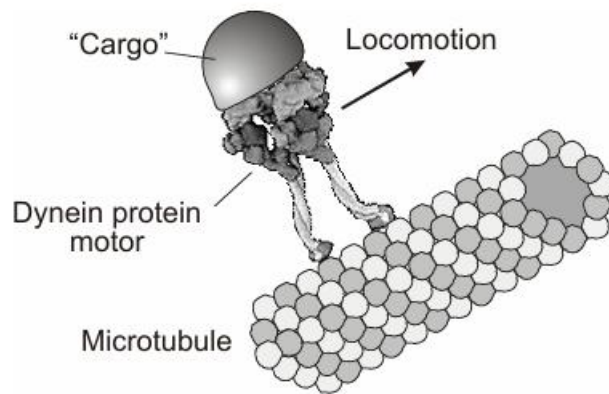
Describe the action of Cyclin D CDK on retinoblastoma (Rb) in the control of the cell cycle.

Phosphorylates Rb/transcription factor inhibitor

Sufficient phosphorylation allows progression to S phase/DNA replication.

2

12 The diagram represents a dynein motor protein “walking” a vesicle along a microtubule.



(a) Name the globular protein subunits of microtubules.

Tubulin

1

(b) The cytoskeleton is dismantled to form the spindle. Name the stage of mitosis when the chromatids are separated.

Anaphase

1

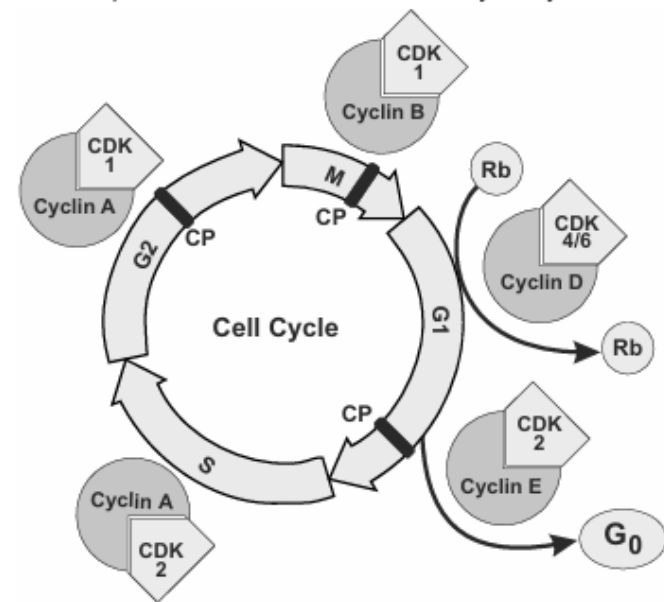
(c) Explain the role of retinoblastoma (Rb) in the control of the cell cycle.

Transcription factor inhibitor

Prevents transcriptions of genes needed for DNA replication/ entry into S phase.

2

13 The diagram below represents the control of the cell cycle by Cdk's.



(a) State what is being monitored in a G1 cell before the cycle can continue.

Cell size/mass

1

(b) (i) Explain how the retinoblastoma protein (Rb) acts as a checkpoint during G1.

TF inhibitor preventing DNA replications being transcribed.

1

(ii) Explain how an accumulation of G1 cyclin-CDK removes the Rb checkpoint and allows the S phase to begin.

Sufficient phosphorylation of Rb inactivates Rb

1

(c) State what occurs during the S phase.

DNA replication

1

14	Describe the control of the cell cycle.	8	15	Describe the structure of spindle fibres and explain their role in the movement of chromosomes during cell division.	4
	1. Progress through the cell cycle is controlled by checkpoints 2. Checkpoints assess the condition of the cell and only allow progression when certain requirements are met 3. Cyclin proteins that accumulate during cell growth are involved in regulating the cycle 4. Cyclins (combine with and) activate cyclin-dependent kinases / CDKs 5. Active CDKs phosphorylate proteins that allow progression only when phosphorylation is sufficient 6. At the G1 checkpoint retinoblastoma protein / Rb inhibits the transcription of genes that code for proteins needed for DNA replication 7. Phosphorylation by G1 cyclin-CDK inhibits the retinoblastoma / Rb and cells progress to S phase 8. At the G2 checkpoint the success of DNA replication / any damage to DNA is assessed 9. DNA damage triggers the activation of p53 / other proteins that stimulate DNA repair / arrest the cell cycle / cause cell death 10. At the metaphase checkpoint progression is paused until the chromosomes are aligned correctly and attached to the spindle 11. Uncontrolled reduction in cell cycle may result in degenerative disease OR Uncontrolled increase in rate of the cell cycle may result in tumour formation 12. A proto-oncogene can mutate to form a tumour - promoting oncogene 13. Apoptosis is triggered by signals that can be external such molecules from lymphocytes OR Apoptosis is triggered by internal signals that can be such as DNA damage causing the activation of p53 tumour-suppressor protein 14. Both types of death signal result in a cascade of caspases / protease enzymes that cause the destruction of the cell 15. Apoptosis is essential to remove cells no longer required for development / during metamorphosis / in the absence of growth factors			1. Cell division requires remodelling of cytoskeleton. 2. Spindle fibres made of microtubules. 3. Composed of tubulin. 4. (Composed of) hollow / straight rods/cylinders/ tubes. Maximum 2 from 1 to 4 5. Attach to chromosomes/ chromatids /centromeres/ kinetochores. 6. Radiate from centrosome/ microtubule organising centre/MTOC. 7. Spindle fibres contract/ shorten. 8. Separate chromatids/ (homologous) chromosomes. Maximum 2 from 5 to 8	
		Any 10 for 1 mark each			

p53 & Apoptosis

1 Which row in the table identifies the mechanism of apoptosis induced as a result of p53 activation?

	Origin of cell death signal		Trigger for cell death	
	External	Internal	Natural killer cell attachment	DNA damage
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

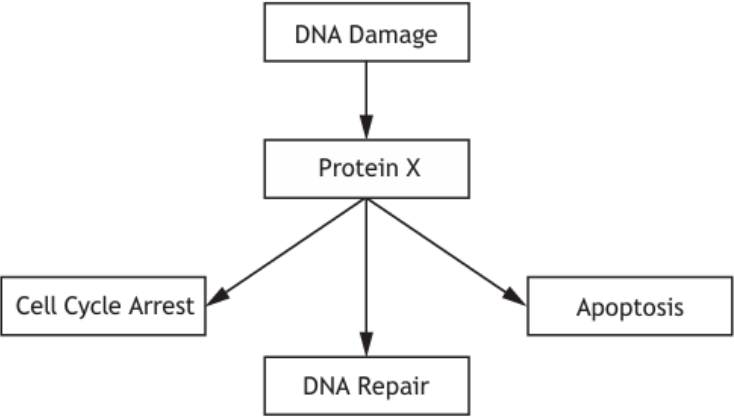
2 Which row in the table describes the states of the proteins p53 and Rb that would increase the rate of cell division?

	Protein	
	p53	Rb
A	activated	phosphorylated
B	inhibited	phosphorylated
C	activated	dephosphorylated
D	inhibited	dephosphorylated

3 Which of the following would **not** be a substrate for caspases?

- A DNA
- B actin
- C histone
- D tubulin

4 The diagram below shows possible outcomes for a cell following DNA damage. Protein X is involved in all three outcomes.



Protein X is

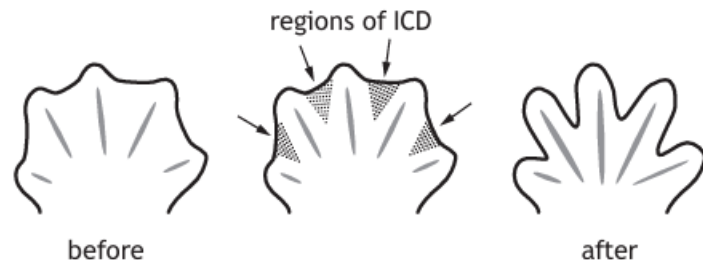
- A Rb
- B p53
- C Cdk
- D caspase.

5 Which line in the table below correctly identifies factors that trigger apoptosis?

	p53 protein	Cell growth factors
A	absent	absent
B	present	present
C	present	absent
D	absent	present

6 Which of the following describes the action of oncogenes?

- A They cause cell proliferation resulting in tumour formation.
- B They encode the proteins that limit cell division.
- C They restrict cell division at checkpoints.
- D They switch genes on during cell differentiation.



- 1 (a) (i) Apoptosis in these cells is triggered by an external signal.
Give an example of an external death signal. 1
- _____
- (ii) Name the type of protease enzyme that causes the destruction of cells undergoing apoptosis. 1
- _____
- b) Apoptosis is essential during development of an organism to remove cells no longer required as development progresses.
State another process in which apoptosis is essential. 1
- _____
2. Give one outcome of p53 activation in a normal cell. 1
- _____

3. State **one** trigger that would stimulate the activation of p53. 1
- _____
4. State one other fate, apart from arrest of the cell cycle, of a cell that has had p53 activated. 1
- _____
5. Describe the action of caspases in cell destruction. 1
- _____
- _____
6. Describe the role of p53 during the G2 checkpoint. 1
- _____
7. Explain the consequence of a mutation of a proto-oncogene into an oncogene. 1
- _____
- _____

8. Write an account of apoptosis.

9

8.

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	External	Internal	Natural killer cell attachment	DNA damage
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

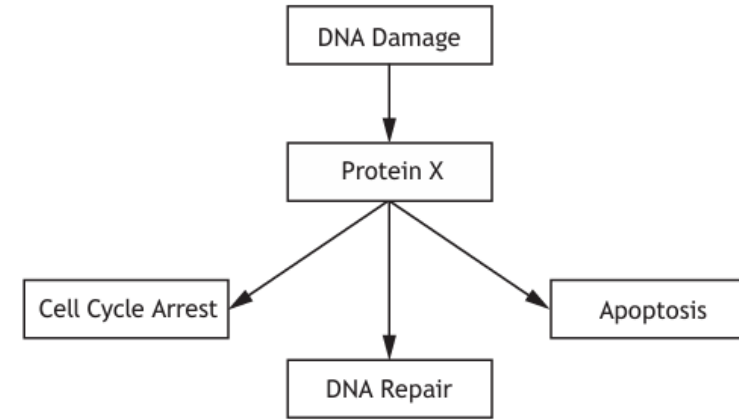
- 2 Which row in the table describes the states of the proteins p53 and Rb that would increase the rate of cell division?

	Protein	
	p53	Rb
A	activated	phosphorylated
B	inhibited	phosphorylated
C	activated	dephosphorylated
D	inhibited	dephosphorylated

- 3 Which of the following would **not** be a substrate for caspases?

- A** DNA
- B actin
- C histone
- D tubulin

- 4 The diagram below shows possible outcomes for a cell following DNA damage. Protein X is involved in all three outcomes.



Protein X is

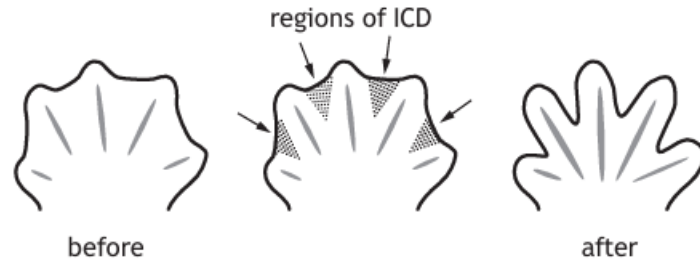
- A Rb
- B** p53
- C Cdk
- D caspase.

- 5 Which line in the table below correctly identifies factors that trigger apoptosis?

	p53 protein	Cell growth factors
A	absent	absent
B	present	present
C	present	absent
D	absent	present

- 6 Which of the following describes the action of oncogenes?

- A** They cause cell proliferation resulting in tumour formation.
- B They encode the proteins that limit cell division.
- C They restrict cell division at checkpoints.
- D They switch genes on during cell differentiation.



- 1 (a) (i) Apoptosis in these cells is triggered by an external signal.
 Give an example of an external death signal. 1
molecules from lymphocytes. OR absence of growth factors.
- (ii) Name the type of protease enzyme that causes the destruction of cells undergoing apoptosis. 1
Caspases
- b) Apoptosis is essential during development of an organism to remove cells no longer required as development progresses.
 State another process in which apoptosis is essential. 1
Metamorphosis OR to remove damaged/cancer cells.
2. Give one outcome of p53 activation in a normal cell. 1
DNA repair stimulated
cell cycle arrested
apoptosis

3. State **one** trigger that would stimulate the activation of p53. 1
molecules from lymphocytes/ absence of growth factors /DNA damage
4. State one other fate, apart from arrest of the cell cycle, of a cell that has had p53 activated. 1
DNA repair stimulated OR apoptosis
5. Describe the action of caspases in cell destruction. 1
break down proteins.
6. Describe the role of p53 during the G2 checkpoint. 1
DNA repair stimulated/arrests cell cycle/apoptosis
7. Explain the consequence of a mutation of a proto-oncogene into an oncogene. 1
Oncogenes cause tumour formation (by cell proliferation)

8. Write an account of apoptosis.

9

1. Programmed cell death
2. Infected cells OR Abnormal / tumour / cancer cells
OR Cells with DNA damage
3. Triggered by cell death signals
4. Death signals activate inactive DNAase
5. Death signals activate inactive proteinases /
caspases
6. DNAases / proteinases / caspases destroy the cell
7. Death signals from outwith the cell bind to surface
receptors
8. This activates a protein cascade that produces active
caspases
9. Death signals come from lymphocytes /
T lymphocytes / natural killer cells
10. Cell death signals may originate within the cell
11. DNA damage results in the presence of p53 protein
12. p53 protein can activate caspase cascade
13. Cells initiate apoptosis in absence of growth factors

Any 9 for 1 mark each

8.